CLAIMS

1. A method of determining the location of a mobile terminal (12) in a given area, comprising the step of including said mobile terminal (12) both in a satellite-based positioning system and in a cellular communications system (14), whereby said mobile terminal (12) is adapted to receive satellite signals from said satellite-based system and to be covered by at least one cell of said cellular communication system (14),

characterized in that the method includes the step of determining at least approximately the coordinates (x, y, z) of said mobile terminal (12) based on both satellite signals received from said satellite-based system and information (52) related to said cellular communication system (14), wherein said coordinates include an altitude coordinate (z) and an estimate of said altitude coordinate (z) is derived from said information related to said cellular communication system.

2. The method of claim 1, characterized in that it includes the steps of:

- providing a geographical data base (52a) including data base items associating to a given set of bi-dimensional positioning coordinates (x_i, y_i) of said mobile terminal (14) in said area corresponding values for said altitude coordinate (z_i),
- accessing said geographical data base (52a) via said mobile terminal (12) whereby said positioning coordinates (x, y, z) as at least approximately determined by said mobile terminal based on said satellite signals are refined via the information derived from said geographical data base (52a).

3. The method of claim 1, characterized in that it includes the step of:

- identifying, in said cellular communications system (14), at least one base station proximate to said mobile terminal (12), said proximate base station having an associated altitude coordinate, and

- using the altitude coordinate of said proximate base station as said estimate of said altitude coordinate (z).

4. The method of claim 1, characterized in that it includes the steps of:

- identifying, in said cellular communications system (14), a plurality of base stations adjacent to said mobile terminal (12), each said adjacent base station having a respective altitude coordinate,

- determining the minimum of said altitude coordinates for said adjacent base stations, and

- using said minimum value as said estimate of said altitude coordinate (z).

5. The method of claim 1, characterized in that it includes the steps of:

- identifying, in said cellular communications system (14), a plurality of base stations adjacent to said mobile terminal (12), each said adjacent base station having a respective altitude coordinate,

- determining an average value for said respective altitude coordinates over said adjacent base stations, and

- using said average value as said estimate of said altitude coordinate (z).

6. The method of claim 5, characterized in that it includes the steps of:

- performing power measurements providing, for each said adjacent base station, a respective power value for said mobile terminal, and

- determining said average value as a weighted average of said respective altitude coordinates values, the weighting being a function of said power values determined for each said adjacent base station.

7. The method of claim 1, characterized in that said positioning coordinates (x, y, z) are determined in an iterative manner by subsequent location steps (1012 to 1022), a new refined estimate of said altitude coordinate (z_i) being used at each step in said iterative process.

8. The method of claim 1, characterized in that it includes the steps of:

- providing (1004) an approximate bi-dimensional positioning (x, y) of said terminal (12) on the basis of said information related to said cellular communication system, and

- determining (400; 1020) said positioning coordinates (x, y, z) of said mobile terminal (12) on the basis of said satellite signals by exploiting said bi-dimensional positioning and said estimate of said altitude coordinate (z).

9. The method of claim 8, characterized in that said determining step includes:

- initially determining (1012) a search area for positioning coordinates of said mobile terminal (12) based on said satellite signals and said estimate of said altitude coordinate (z), and

- subsequently (420) identifying said positioning coordinates (x, y, z) within said search area based on information related to said cellular communication system (14).

10. The method of claim 9, characterized in that it includes the steps of:

- defining the search area for said positioning coordinates (x, y, z,) in the form of a hyperbolic set of points, and

- determining said positioning coordinates (x, y, z) within said hyperbolic set of points by using said information related to said cellular communication system (14).

11. The method of claim 2, characterized in that it includes the steps of:

- determining (1004) a first set of values for said location coordinates (x_0, y_0, z_0) on the basis of said information related to said cellular communication system,

- acquiring (1010) said satellite signals from said satellite-based system and deriving therefrom an area likely to include the mobile terminal (12),

- providing a new set of values (x_1, y_1, z_1) of said location coordinates by:

- i) effecting, based on said information related to said cellular communication system, a bi-dimensional positioning (x, y) of said mobile terminal (12) within said area likely to include the mobile terminal (12), and

- ii) accessing said geographical data base (52a) and associating to the bi-dimensional positioning coordinates (x_1, y_1) of said mobile terminal (14) within said area a corresponding value for said altitude coordinate (z_1).

12. The method of claim 11, characterized in that it includes the steps of:

- determining (1022) the distance between said new set of values of said location coordinates (x_1, y_1, z_1) and said first set of values for said location coordinates (x_0, y_0, z_0), and

- comparing (1022) said distance with a threshold indicative of the degree of accuracy pursued in the location action, and

- if said distance is higher than said threshold, starting an iterative process wherein said area likely to include the mobile terminal (12) is re-defined on the basis of said satellite signals from said satellite-based system and the latest value available for said altitude coordinate (z) and said steps of effecting said bi-dimensional positioning (x, y), accessing said geographical data base (52a) and associating to the bi-dimensional positioning coordinates (x_i, y_i) of said mobile terminal (14) within said area a corresponding value for said altitude coordinate (z_i) are repeated, wherein said steps of bi-dimensional positioning (x, y) is effected over said re-defined area.

13. The method of claim 12, characterized in that said iterative process includes the steps of:

- determining (1022) the distance between the sets of values of said location coordinates as available before (x_{i-1}, y_{i-1}, z_{i-1}) and after (x_i, y_i, z_i) the current iteration step, and

- comparing (1022) said distance with a threshold indicative of the degree of accuracy pursued in the location action, and

- if said distance is higher than said threshold, running a further iteration step wherein said area likely to include the mobile terminal (12) is further re-defined on the basis of said satellite signals from said satellite-based system and the latest value available for said altitude coordinate (z_i) and said steps of effecting said bi-dimensional positioning (x, y), accessing said geographical data base (52a) and associating to the bi-dimensional positioning

coordinates (x_i, y_i) of said mobile terminal (14) within said area a corresponding value for said altitude coordinate (z_i) are further repeated, wherein said step of bi-dimensional positioning (x, y) is effected over said further re-defined area.

14. The method of claim 1, characterised in that it includes the step of determining at least approximately said coordinates (x, y, z), based on satellite signals received from less than three satellites of said satellite-based system.

15. An arrangement including:

- a satellite-based positioning system,
- a cellular communications system (14), and
- at least one mobile terminal (12) adapted to receive in a given area satellite signals from said satellite-based system and to be covered by at least one cell of said cellular communication system (14),

characterized in that it includes at least one processing module (25, 55) configured for determining at least approximately the coordinates (x, y, z), including an altitude coordinate (z), of said mobile terminal (12) based on both satellite signals received from said satellite-based system and information (52) related to said cellular communication system (14), said at least one module (25, 55) being configured for deriving an estimate of said altitude coordinate (z) from said information related to said cellular communication system.

16. The arrangement of claim 15, characterized in that it includes a geographical data base (52a) including data base items associating to a given set of bi-dimensional positioning coordinates (x_i, y_i) of said mobile terminal (14) in said area corresponding values for said altitude coordinate (z_i), and in that said at least one module (25, 55) is configured for accessing

said geographical data base (52a) whereby said positioning coordinates (x, y, z) as at least approximately determined based on said satellite signals are refined via the information derived from said geographical data base (52a).

17. The arrangement of claim 15, characterized in that:

- said cellular communications system (14) includes at least one base station proximate to said mobile terminal (12), said proximate base station having an associated altitude coordinate, and

- said at least one module (25, 55) is configured for using the altitude coordinate of said proximate base station as said estimate of said altitude coordinate (z).

18. The arrangement of claim 15, characterized in that:

- said cellular communications system (14) includes a plurality of base stations adjacent to said mobile terminal (12), each said adjacent base station having a respective altitude coordinate,

- said at least one module (25, 55) is configured for using as said estimate of said altitude coordinate (z) one of the minimum of said altitude coordinates for said adjacent base stations and an average value for said respective altitude coordinates over said adjacent base stations.

19. The arrangement of claim 18, characterized in that said at least one module (25, 55) is configured for performing power measurements providing, for each said adjacent base station, a respective power value for said mobile terminal, and determining said average value as a weighted average of said respective altitude coordinates values, the weighting being a function of

said power values determined for each said adjacent base station.

20. The arrangement of claim 15, characterized in that it includes at least one module (25, 55) configured for determining said positioning coordinates (x, y, z) in an iterative manner by subsequent location steps (1012 to 1022), a new refined estimate of said altitude coordinate (z_i) being used at each step in said iterative process.

21. The arrangement of claim 15, characterized in that it includes at least one module (25, 55) configured for:

- providing (1004) an approximate bi-dimensional positioning (x, y) of said terminal (12) on the basis of said information related to said cellular communication system, and

- determining (400; 1020) said positioning coordinates (x, y, z) of said mobile terminal (12) on the basis of said satellite signals by exploiting said bi-dimensional positioning and said estimate of said altitude coordinate (z).

22. The arrangement of claim 21, characterized in that it includes at least one module (25, 55) configured for:

- initially determining (1012) a search area for positioning coordinates of said mobile terminal (12) based on said satellite signals and said estimate of said altitude coordinate (z), and

- subsequently (420) identifying said positioning coordinates (x, y, z) within said search area based on information related to said cellular communication system (14).

23. The arrangement of claim 22, characterized in that it includes at least one module (25, 55) configured for:

- defining the search area for said positioning coordinates (x, y, z,) in the form of a hyperbolic set of points, and

- determining said positioning coordinates (x, y, z) within said hyperbolic set of points by using said information related to said cellular communication system (14).

24. The arrangement of claim 16, characterized in that it includes at least one module (25, 55) configured for:

- determining (1004) a first set of values for said location coordinates (x_0, y_0, z_0) on the basis of said information related to said cellular communication system,

- acquiring (1010) said satellite signals from said satellite-based system and deriving therefrom an area likely to include the mobile terminal (12),

- providing a new set of values (x_1, y_1, z_1) of said location coordinates by:

- i) effecting, based on said information related to said cellular communication system, a bi-dimensional positioning (x, y) of said mobile terminal (12) within said area likely to include the mobile terminal (12), and

- ii) accessing said geographical data base (52a) and associating to the bi-dimensional positioning coordinates (x_1, y_1) of said mobile terminal (14) within said area a corresponding value for said altitude coordinate (z_1).

25. The arrangement of claim 24, characterized in that it includes at least one module (25, 55) configured for:

- determining (1022) the distance between said new set of values of said location coordinates (x_1, y_1, z_1)

and said first set of values for said location coordinates (x_0, y_0, z_0), and

- comparing (1022) said distance with a threshold indicative of the degree of accuracy pursued in the location action, and

- if said distance is higher than said threshold, starting an iterative process wherein said area likely to include the mobile terminal (12) is re-defined on the basis of said satellite signals from said satellite-based system and the latest value available for said altitude coordinate (z) and said steps of effecting said bi-dimensional positioning (x, y), accessing said geographical data base (52a) and associating to the bi-dimensional positioning coordinates (x_i, y_i) of said mobile terminal (14) within said area a corresponding value for said altitude coordinate (z_i) are repeated, wherein said steps of bi-dimensional positioning (x, y) is effected over said re-defined area.

26. The arrangement of claim 25, characterized in that it includes at least one module (25, 55) configured for running said iterative process by:

- determining (1022) the distance between the sets of values of said location coordinates as available before (x_{i-1}, y_{i-1}, z_{i-1}) and after (x_i, y_i, z_i) the current iteration step, and

- comparing (1022) said distance with a threshold indicative of the degree of accuracy pursued in the location action, and

- if said distance is higher than said threshold, running a further iteration step wherein said area likely to include the mobile terminal (12) is further re-defined on the basis of said satellite signals from said satellite-based system and the latest value available for said altitude coordinate (z_i) and said

steps of effecting said bi-dimensional positioning (x, y), accessing said geographical data base (52a) and associating to the bi-dimensional positioning coordinates (x_i, y_i) of said mobile terminal (14) within said area a corresponding value for said altitude coordinate (z_i) are further repeated, wherein said step of bi-dimensional positioning (x, y) is effected over said further re-defined area.

27. A mobile terminal (12) for use in a satellite-based positioning system and a cellular communications system (14), the mobile terminal (12) being adapted to receive in a given area satellite signals from said satellite-based system and to be covered by at least one cell of said cellular communication system (14), characterized in that said at least one mobile terminal includes a processing module (25) configured for determining at least approximately the coordinates (x, y, z), including an altitude coordinate (z), of the mobile terminal in said area, based on both satellite signals received from said satellite-based system and information (52) related to said cellular communication system (14), and wherein said processing module (25) is configured for deriving an estimate of said altitude coordinate (z) from said information related to said cellular communication system.

28. The terminal of claim 27, characterized in that the terminal is adapted to be operatively associated (14) with a geographical data base (52a) including data base items associating to a given set of bi-dimensional positioning coordinates (x_i, y_i) of said mobile terminal (14) in said area corresponding values for said altitude coordinate (z_i), and in that said mobile terminal (12) is configured for accessing said geographical data base (52a) whereby said positioning coordinates (x, y, z) as at least approximately

determined by said mobile terminal based on said satellite signals are refined via the information derived from said geographical data base (52a).

29. The terminal of claim 27, characterized by being configured for using as said estimate of said altitude coordinate (z) the altitude coordinate of a proximate base station in said cellular communications system (14).

30. The terminal of claim 27, characterized by being configured for using as said estimate of said altitude coordinate (z) one of the minimum of altitude coordinates for a plurality of adjacent base stations in said cellular communications system (14) and an average value for said respective altitude coordinates over said adjacent base stations.

31. The terminal of claim 30, characterized by being configured for performing power measurements providing, for each said adjacent base station, a respective power value for said mobile terminal, and determining said average value as a weighted average of said respective altitude coordinates values, the weighting being a function of said power values determined for each said adjacent base station.

32. The terminal of claim 27, characterized by being configured for determining said positioning coordinates (x, y, z) in an iterative manner by subsequent location steps (1012 to 1022), a new refined estimate of said altitude coordinate (z_i) being used at each step in said iterative process.

33. The terminal of claim 27, characterized by being configured for:

- providing (1004) an approximate bi-dimensional positioning (x, y) of said terminal (12) on the basis of said information related to said cellular communication system, and

- determining (400; 1020) said positioning coordinates (x, y, z) of said mobile terminal (12) on the basis of said satellite signals by exploiting said bi-dimensional positioning and said estimate of said altitude coordinate (z).

34. The terminal of claim 33, characterized by being configured for:

- initially determining (1012) a search area for positioning coordinates of said mobile terminal (12) based on said satellite signals and said estimate of said altitude coordinate (z), and

- subsequently (420) identifying said positioning coordinates (x, y, z) within said search area based on information related to said cellular communication system (14).

35. The terminal of claim 27, characterized by being configured for:

- defining the search area for said positioning coordinates (x, y, z,) in the form of a hyperbolic set of points, and

- determining said positioning coordinates (x, y, z) within said hyperbolic set of points by using said information related to said cellular communication system (14).

36. The terminal of claim 27, characterized by being configured for:

- determining (1004) a first set of values for said location coordinates (x_0, y_0, z_0) on the basis of said information related to said cellular communication system,

- acquiring (1010) said satellite signals from said satellite-based system and deriving therefrom an area likely to include the mobile terminal (12),

- providing a new set of values (x_1, y_1, z_1) of said location coordinates by:

- i) effecting, based on said information related to said cellular communication system, a bi-dimensional positioning (x, y) of said mobile terminal (12) within said area likely to include the mobile terminal (12), and

- ii) accessing said geographical data base (52a) and associating to the bi-dimensional positioning coordinates (x_1, y_1) of said mobile terminal (14) within said area a corresponding value for said altitude coordinate (z_1).

37. The terminal of claim 36, characterized by being configured for:

- determining (1022) the distance between said new set of values of said location coordinates (x_1, y_1, z_1) and said first set of values for said location coordinates (x_0, y_0, z_0), and

- comparing (1022) said distance with a threshold indicative of the degree of accuracy pursued in the location action, and

- if said distance is higher than said threshold, starting an iterative process wherein said area likely to include the mobile terminal (12) is re-defined on the basis of said satellite signals from said satellite-based system and the latest value available for said altitude coordinate (z) and said steps of effecting said bi-dimensional positioning (x, y), accessing said geographical data base (52a) and associating to the bi-dimensional positioning coordinates (x_1, y_1) of said mobile terminal (14) within said area a corresponding value for said altitude coordinate (z_1) are repeated, wherein said steps of bi-dimensional positioning (x, y) is effected over said re-defined area.

38. The terminal of claim 37, characterized by being configured for running said iterative process by:

- determining (1022) the distance between the sets of values of said location coordinates as available before (x_{i-1}, y_{i-1}, z_{i-1}) and after (x_i, y_i, z_i) the current iteration step, and

- comparing (1022) said distance with a threshold indicative of the degree of accuracy pursued in the location action, and

- if said distance is higher than said threshold, running a further iteration step wherein said area likely to include the mobile terminal (12) is further re-defined on the basis of said satellite signals from said satellite-based system and the latest value available for said altitude coordinate (z_i) and said steps of effecting said bi-dimensional positioning (x, y), accessing said geographical data base (52a) and associating to the bi-dimensional positioning coordinates (x_i, y_i) of said mobile terminal (14) within said area a corresponding value for said altitude coordinate (z_i) are further repeated, wherein said step of bi-dimensional positioning (x, y) is effected over said further re-defined area.

39. A computer program product directly loadable in the memory of at least one computer and including software code portions for performing the method of any of claims 1 to 14.

40. A computer program product directly loadable in the memory of a computer and including software code portions for implementing the terminal of any of claims 27 to 38.